

OBJECTIVE

Investigate the physical mechanisms that limit gas recovery from tight rock formations to allow long-term gas recovery

MOTIVATION

Unconventional production is the largest source of U.S. natural gas supply // U.S. EIA Annual Energy Outlook 2009 with Projections to 2030

U.S. estimated shale, tight sand, and CBM gas resources: over 8,000 Tcf // Holditch S.A.: SPE 103356

U.S. gas consumption: 22 Tcf / year // U.S. EIA

APPROACH

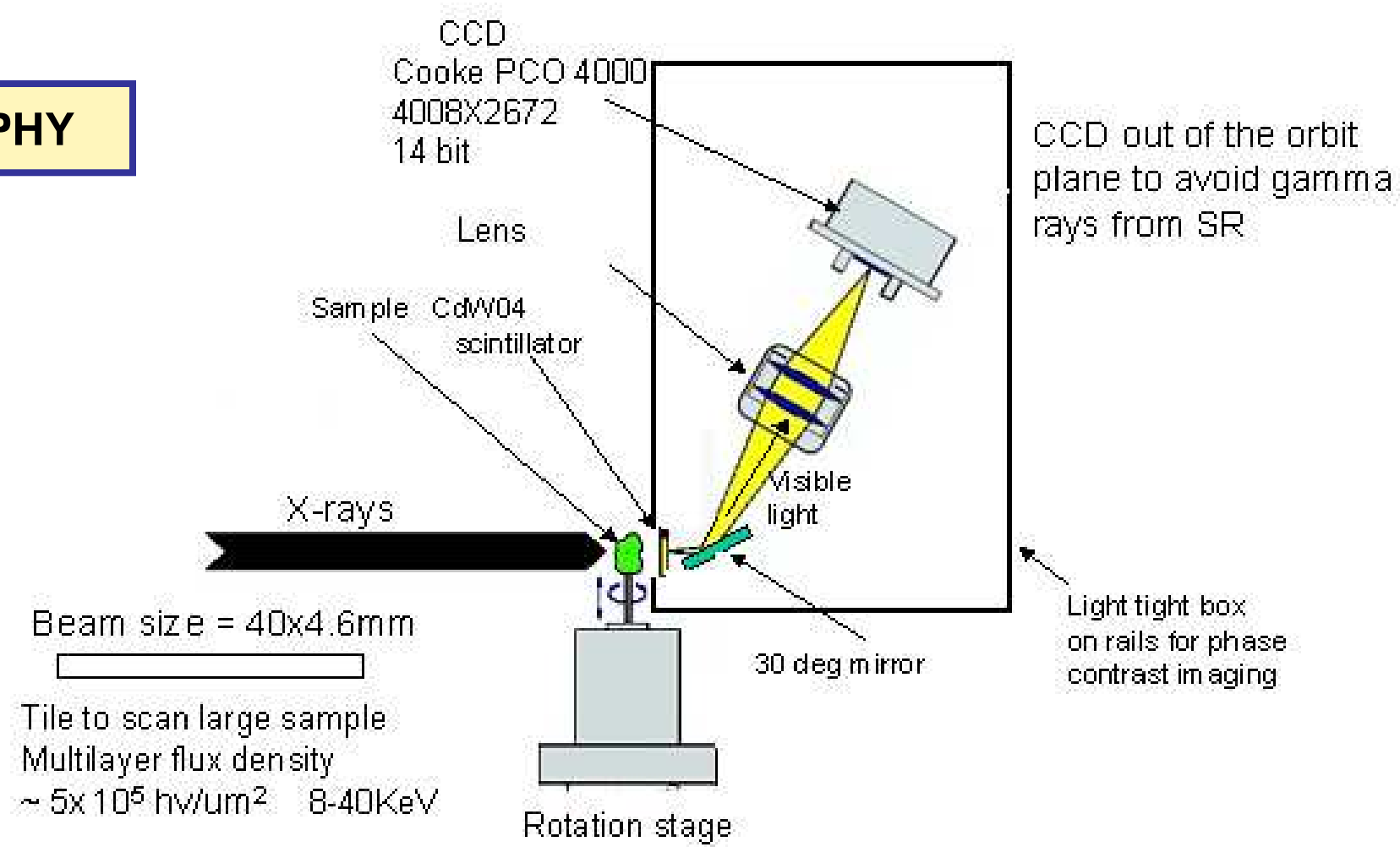
Acquire high-resolution 3D images of gas-bearing shale rocks using

- Advanced Light Source (ALS) microtomography facility
- Focused Ion Beam (FIB) technology,

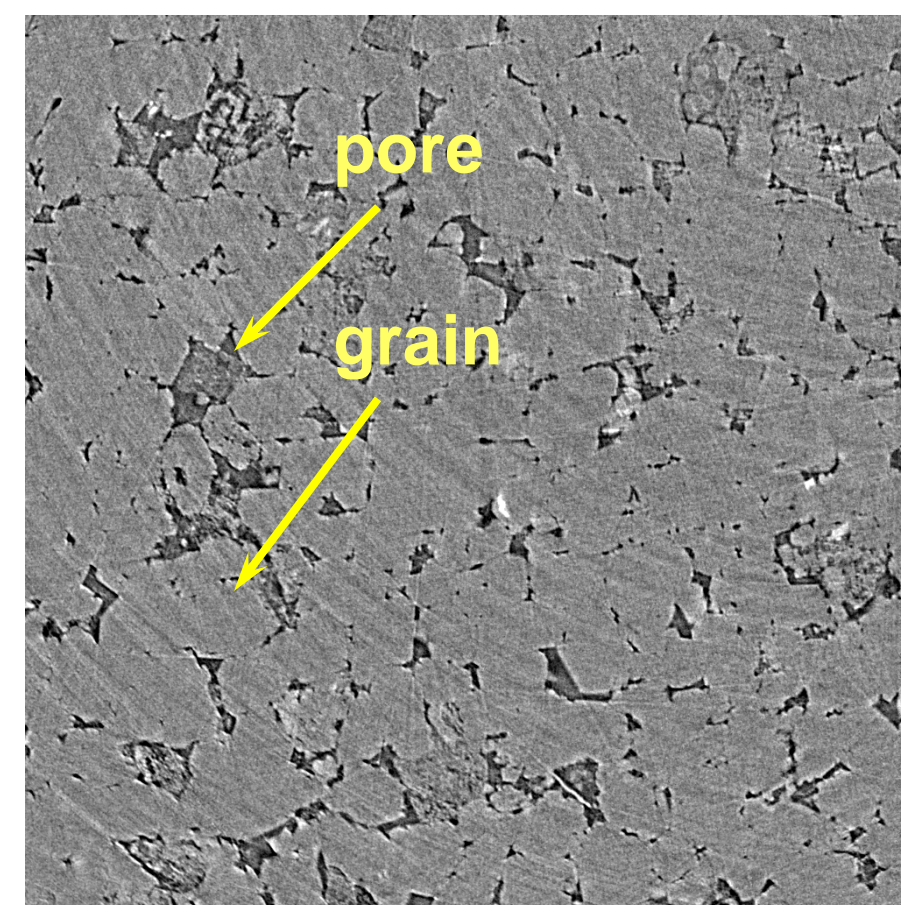
Analyze these images using Maximal Inscribed Spheres-type (MIS) methods in order to estimate gas shale and tight sand flow properties at different conditions

Apply the results to modeling of the impact of retrograde condensation at the fracture-matrix interface on the gas flow into the well

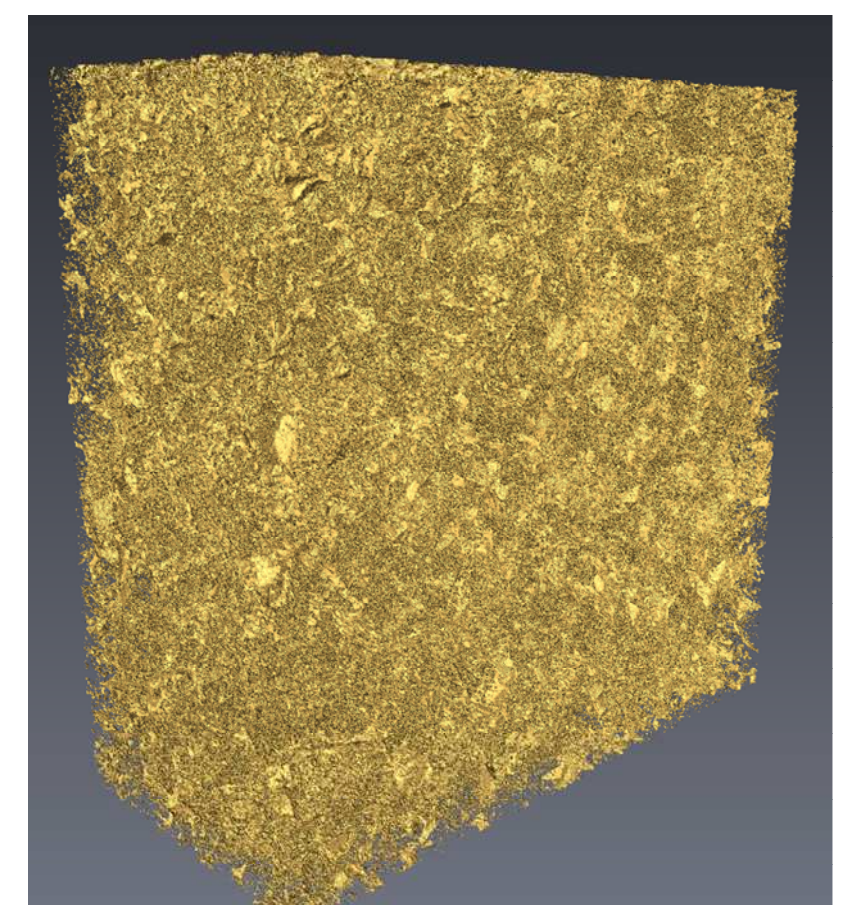
MICROTOMOGRAPHY



Schematic layout of the microtomography end station at the ALS

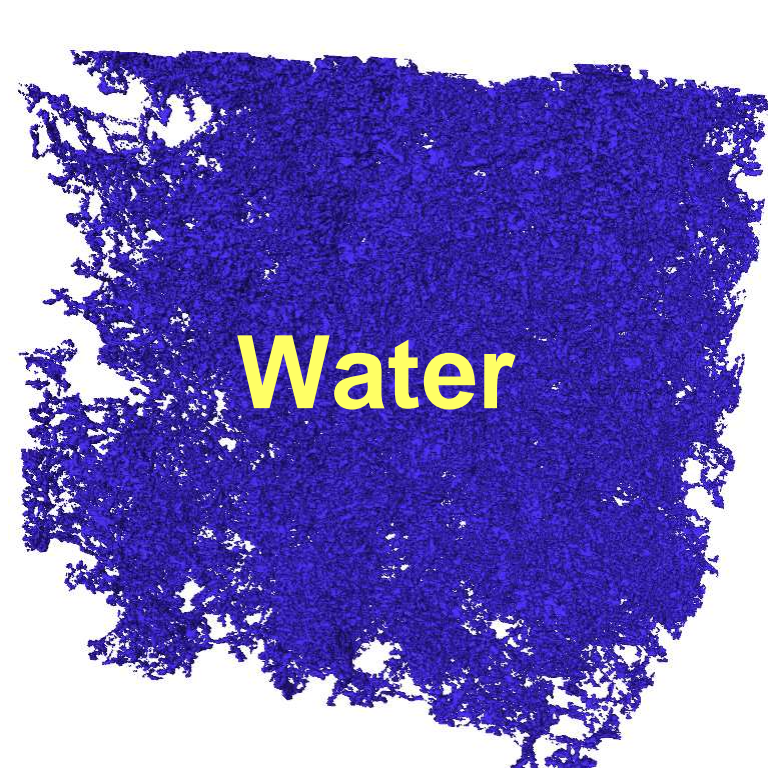
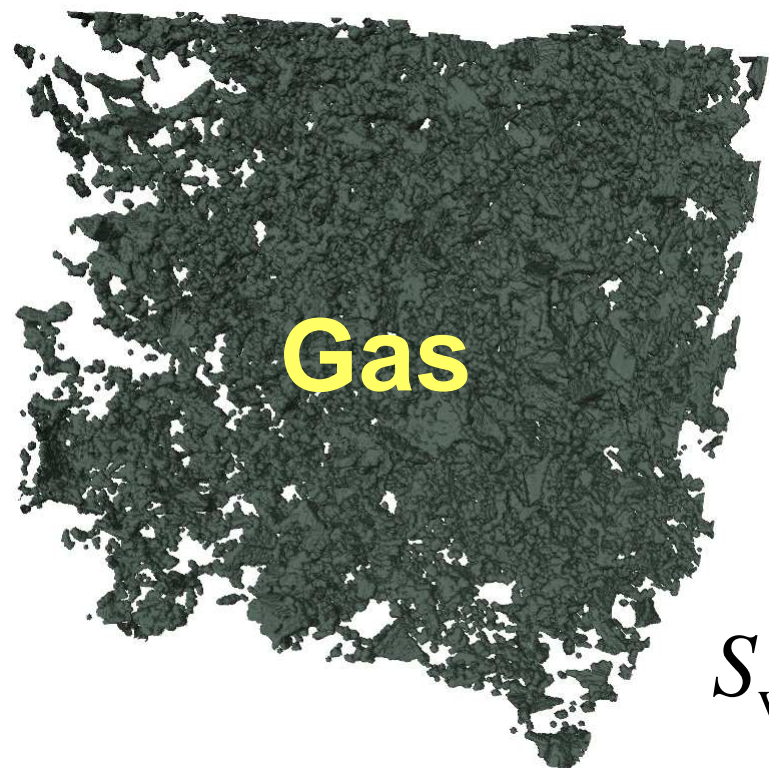


Tight sand: 2D cross-section
Dimensions: 1.7x1.7 mm
Resolution: 1.7 micron

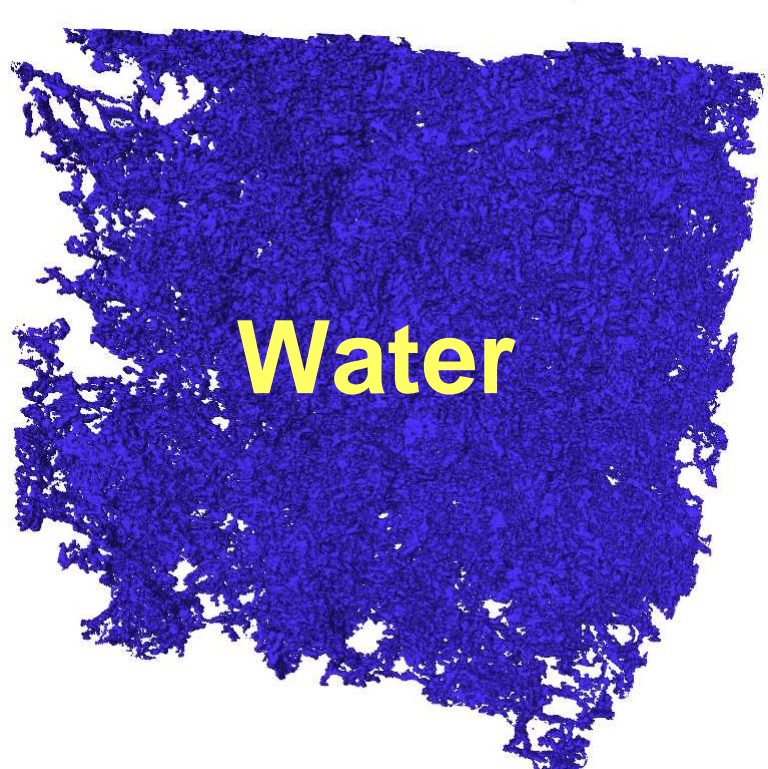
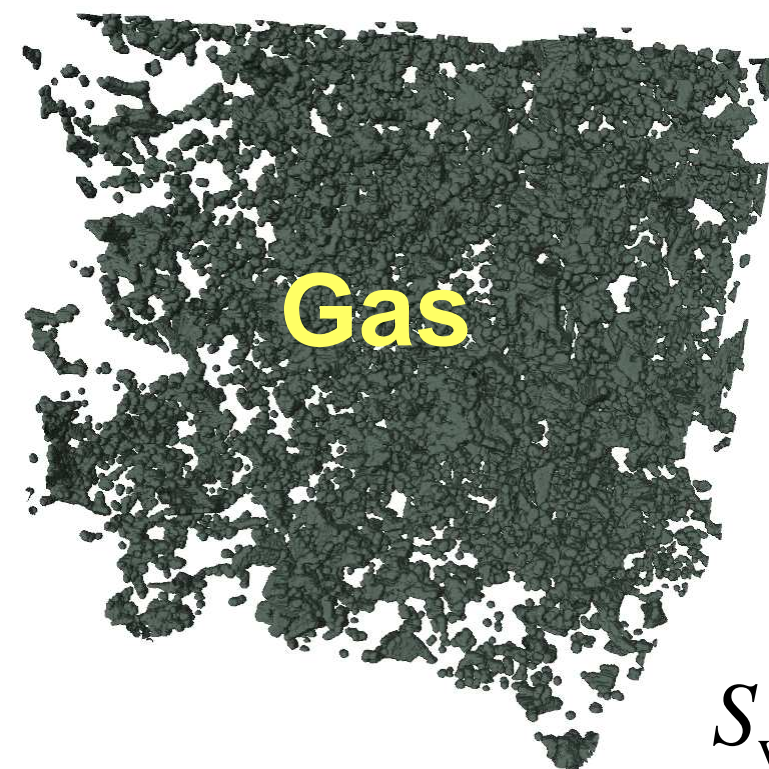


Tight sand: 3D reconstruction of the pore space
Dimensions: 1.7x1.7x0.85 mm
Resolution: 1.7 micron

MIS SIMULATIONS



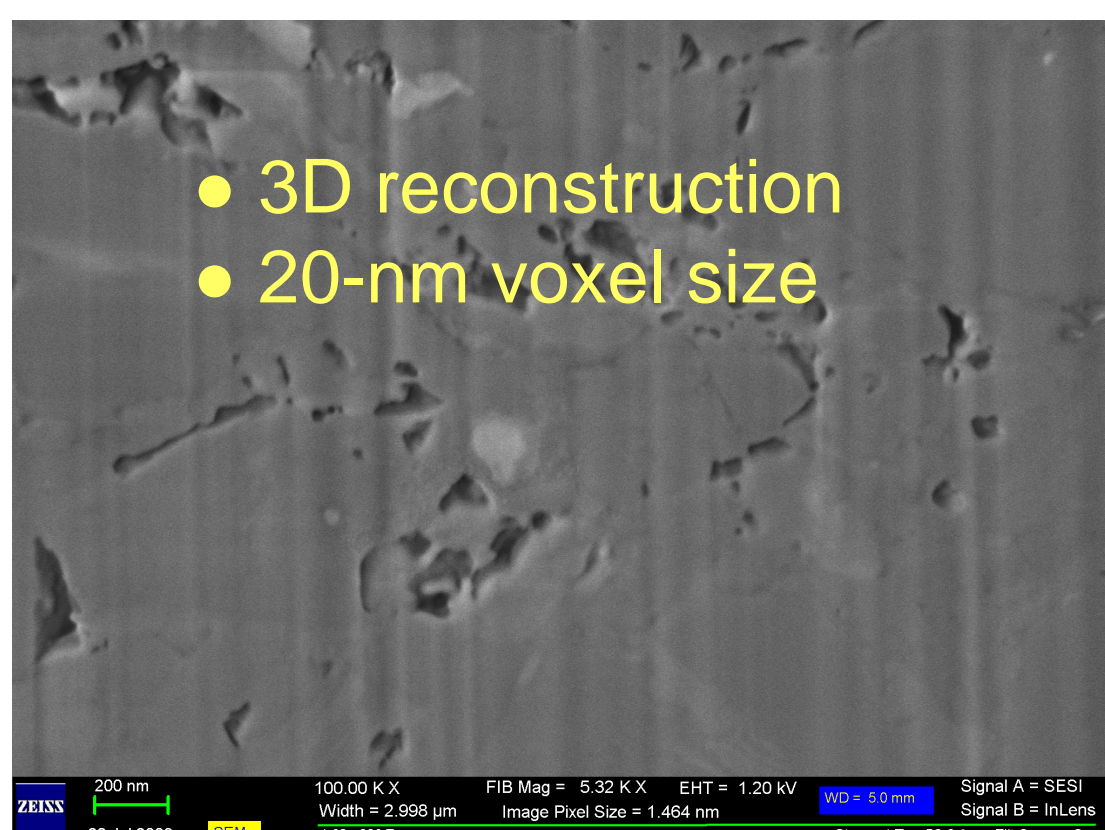
$S_w = 24\%$



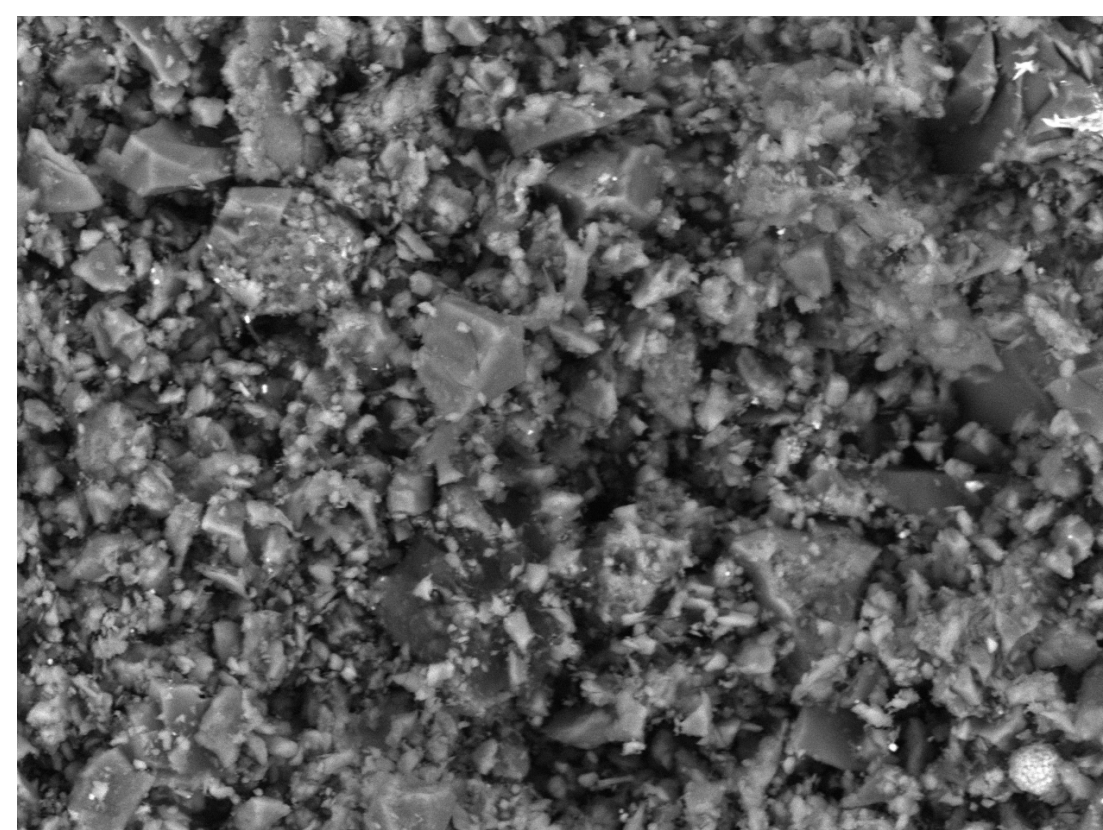
$S_w = 45\%$

Gas becomes disconnected at moderate (<50%) water saturation

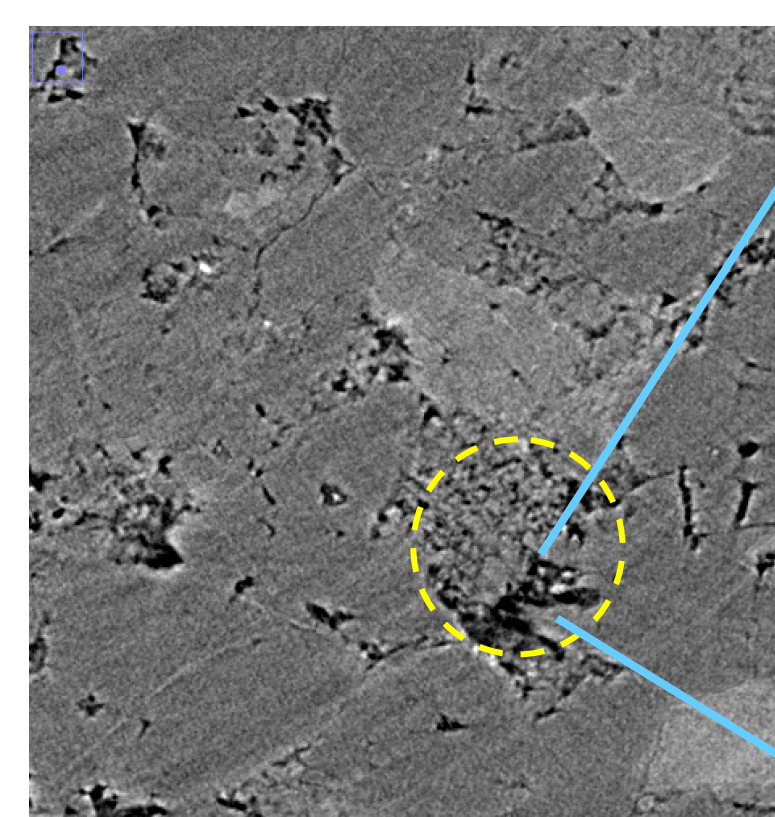
FIB



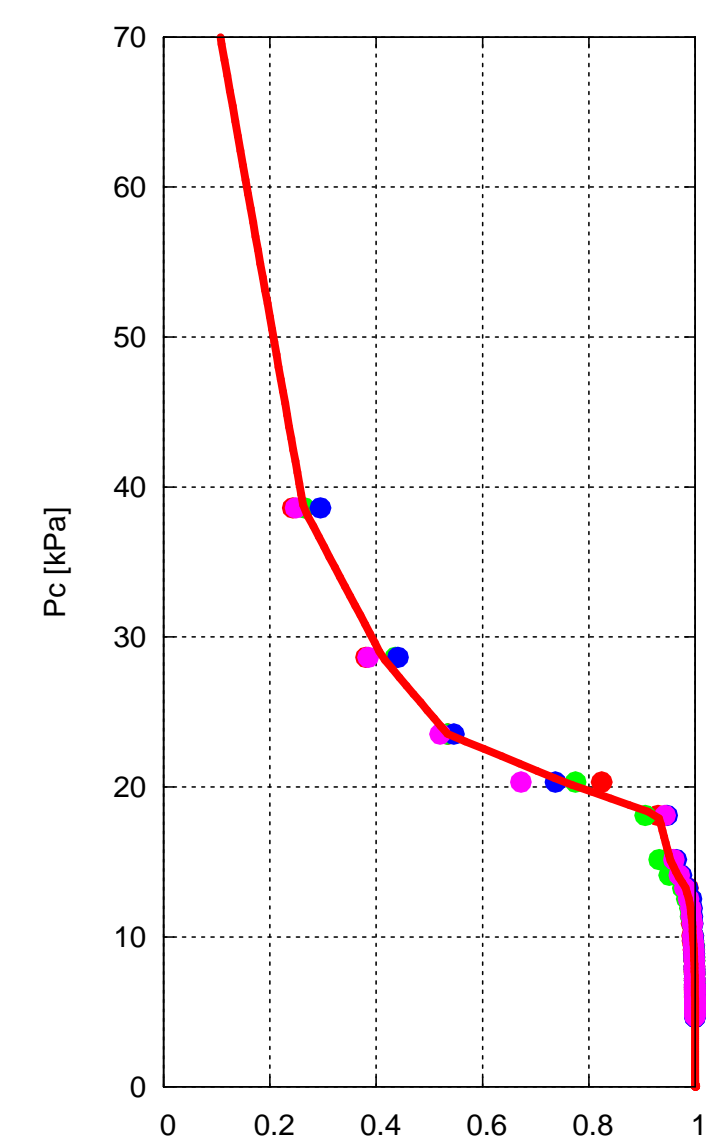
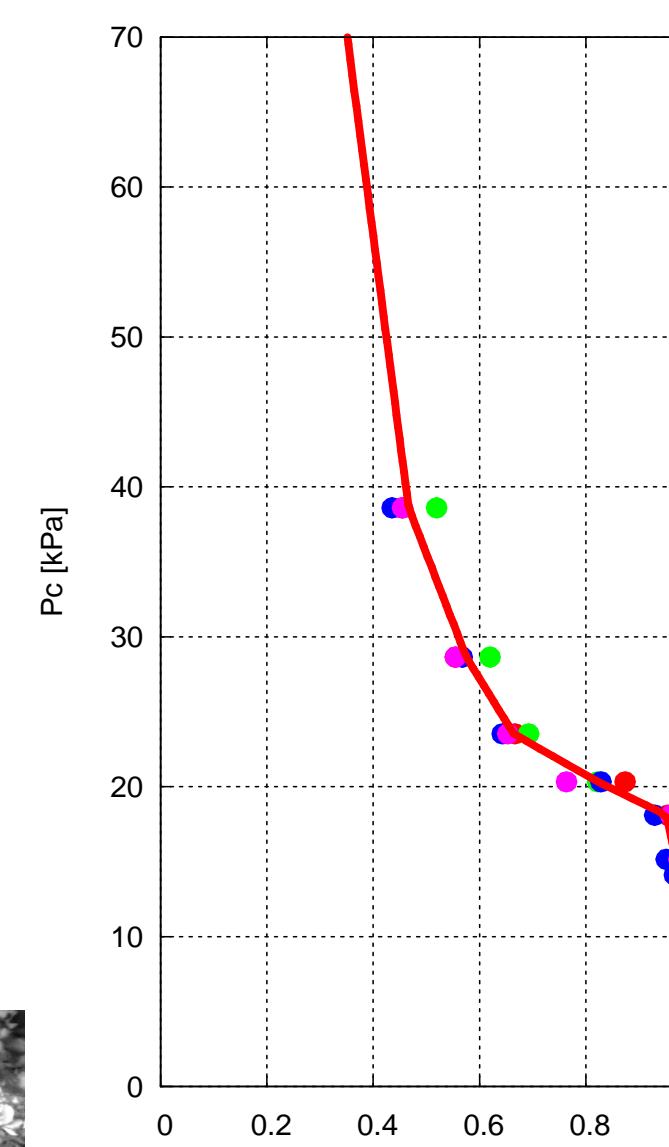
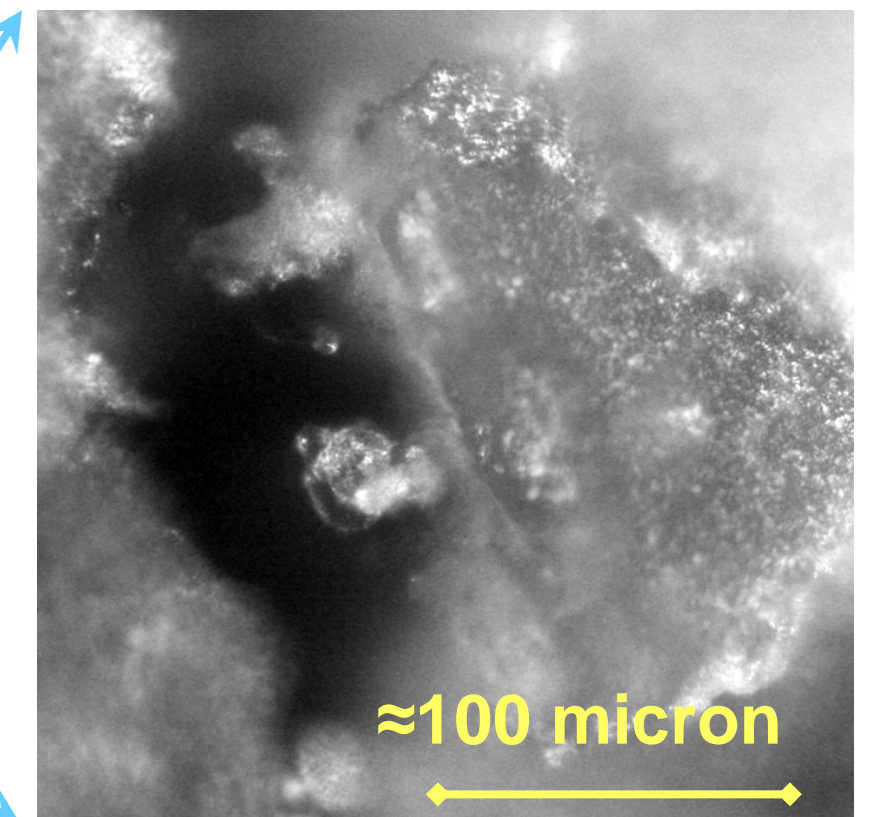
Shale: Focused Ion Beam Milling, SEM Imaging



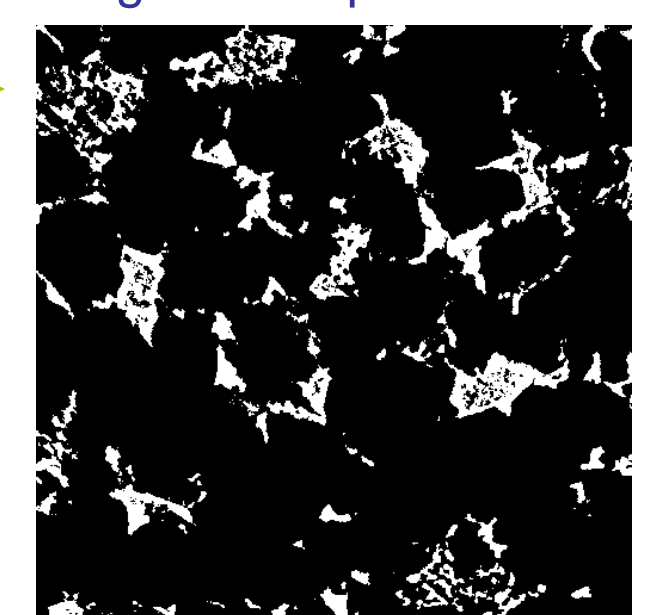
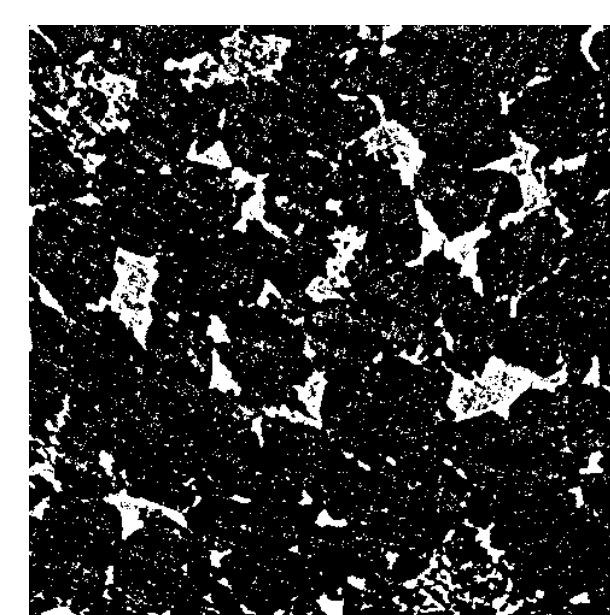
Shale: Electron microscopy



Tight sand: zooming into the pores
NB: not the same location is displayed



3D cluster-based digital image cleanup



Significant disconnected porosity
Connected via sub-resolution pores?

ACKNOWLEDGEMENTS

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